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RESEARCH NOTE

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CHECKING THE CALIBRATION OF NUCLEAR SOIL MOISTURE AND DENSITY MEASURING EQUIPMENT

The use of nuclear equipment for measuring soil moisture and density continues to increase in long-term soil studies as well as for those of short duration. Manufacturers of commercially available nuclear soil moisture and density measuring probes furnish a calibration curve with each probe as well as a shield for making a "standard" count. The calibration curve makes it possible to convert a recorded number of probe impulses into a related density or moisture value. The shield serves as one check on aging, drifting, or other changes within a nuclear probe. Such changes may have a significant effect, especially in long-term soil studies.

One check, however, is insufficient for determining the slope of the calibration curve. Furthermore, our paraffin-lead shield appears to be slightly sensitive to temperature, yielding somewhat different impulse rates in winter than in summer. Three readings--in air, shield, and water--provide a much better check of the calibration curve and may be adequate for many short-term studies. But water is rather unsatisfactory as a permanent check medium because it hastens rusting of the steel drums used to contain the media and freezes during cold weather. So we have prepared additional, more permanent checks so that we can do intensive calibration checking of all our nuclear probes at any season of the year.

These checks consist of 55-gallon steel barrels filled with common materials of various moisture equivalents and densities. We designed our containers so that the access tubes for the subsurface probes enter the drums from the side rather than the top. This leaves the whole top free for checking surface probes (fig. 1).

FIGURE 1.--Steel-drum containers for check media can accommodate both surface and subsurface nuclear probes.

Probes must be checked one at a time; when a nuclear probe is in use, whether for field or check measurements, all other nuclear probes should be 20 or more feet away in order to prevent interference between probes.

The drums, about 2 feet in diameter and 3 feet deep, are smaller than the minimum size considered by some investigators to be infinite to nuclear soil moisture probe radiation.[1/] However, our work so far indicates that a 24-inch-diameter sample is large enough for the equipment we are using.[2/] So, as long as these checks remain in their original setting and condition, they are expected to be adequate for our long-term calibration checking purposes.

1/ Van Bavel, C. H. M., Nielsen, D. R., and Davidson, J. M. Calibration and characteristics of two neutron moisture probes. Soil Sci. Soc. Amer. Proc. 25: 329-334. 1961.

2/ Marston, Richard B. Characteristics of a commercially-available, surface moisture, nuclear probe. Internatl. Assoc. Sci. Hydrol. Bul. IX^{e} No. 2, pp. 80-89, illus. 1964.

Table 1.--Contents of local checks prepared for surface and subsurface moisture nuclear probes

Sand (Pounds)	Alum (Pounds)	Theoretical water equivalent		Calibration curve values
		Pounds per cubic foot	Percent by volume	Percent by volume
0	501	27.07	43.4	40.1
513	236	15.26	24.5	26.9
615	177	11.01	17.7	19.5
716	117	7.03	11.3	12.5
798	59	3.66	5.9	6.5
808	0	0	0	.7

To provide a wide range of moisture values we filled one drum with alum, one with sand, and four with mixtures of sand and alum (table 1). The alum has a chemical formula of NH_4 Al $(SO_4)_2$ + $(12H_2O)$, a molecular weight of 453.32 grams, and a bulk density of 0.91. Therefore, the equivalent moisture content of the alum is 43.4 Pv (percent by volume).[3/] Varying the proportions of sand and alum gave theoretical water equivalent values for our local standards that ranged from this maximum of 43.4 Pv down to 0.

We had hoped that these same samples could also be used for checking the calibration of our density probes, but the sand and alum combinations did not have a wide enough range in density, 105 and 65 pounds per square foot. So we filled four additional drums with materials having a much wider range in density (3 to 148 pounds per square foot): air-dry clay, calcined clay, plastic foam, and road-bed gravel.

3/ Nuclear-Chicago Corporation. Operation and maintenance manual, Model P-19, subsurface, soil moisture probe. 21 pp., illus. [n. d.].

These standard checks have worked satisfactorily over a wide range of weather conditions. Readings in cold weather compare favorably with those in hot, humid conditions. They have not been complicated by condensation within the standards or on the probes. We eliminated the possibility of changes in density at the top of the barrels by compacting the material as it was placed in the drum.

RECOMMENDATIONS

Users of soil moisture and density measuring nuclear probes should check the general operation of their equipment by making a "standard" or "shield" reading several times during each day of use. In short-term studies they can easily and quickly make additional calibration curve check readings with the probes suspended in air and on or under water. If such nuclear equipment is to be used in long-term studies, however, a group of standard checks should be assembled to facilitate more intensive checking to detect changes or drift in the calibration curves.

Sand, alum, and mixtures of sand and alum make satisfactory checks for moisture measuring nuclear probes.

Road-bed gravel, calcined clay, air-dry clay, and polyurethane foam may be used in separate drums to supplement the all-sand and all-alum drums so as to produce a wide enough range of densities for checking density probes.

Checks should be prepared so that both surface and subsurface probes can be checked on them. This can be done by inserting the access tube for the subsurface probes through the side of the container leaving the top surface free.

Richard B. Marston, formerly research forester
Central States Forest Experiment Station
Columbus, Ohio (now with the Pacific Northwest Water Laboratory, U.S. Public Health Service, Corvallis, Oregon)